(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 April 2002 (18.04.2002)

PCT

(10) International Publication Number
WO 02/31287 A1

(51) International Patent Classification⁷: E04C 2/04

(21) International Application Number: PCT/US01/30967

(22) International Filing Date: 3 October 2001 (03.10.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/239,155 10 October 2000 (10.10.2000) US

(71) Applicants *(for all designated States except US)*: **JAMES HARDIE RESEARCH PTY LIMITED** [AU/AU]; Level 1, Research and Product Development Building, 10 Colquhoun Street, Rosehill, New South Wales 2142 (AU). **GLEESON, James, A.** [AU/AU]; 11 Blackwood Road, North Curl, New South Wales 2099 (AU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **DEFORD, Harvey, Dale** [US/US]; 6844 Nevada Court, Rancho Cucamonga, CA 91701 (US). **MERKLEY, Donald, J.** [US/US]; 5054 Klusman Avenue, Alta Loma, CA 91737 (US).

(74) Agent: **DELANEY, Karoline, A.**; KNOBBE, MARTENS, OLSON AND BEAR, LLP, 620 Newport Center Drive, 16 Floor, Newport Beach, CA 92660 (US).

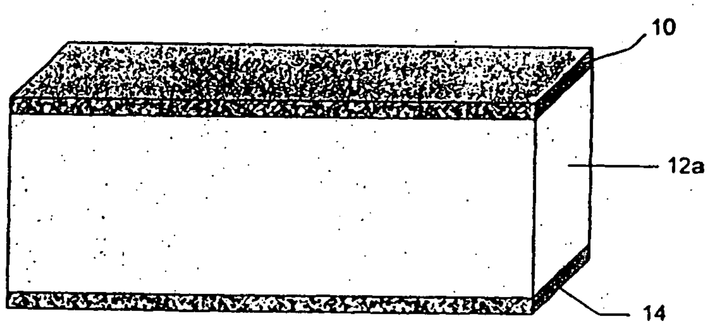
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: COMPOSITE BUILDING MATERIAL



WO 02/31287 A1

(57) Abstract: This invention generally pertains to a composite building material comprising a lightweight core with a thin fiber cement facing on one side of the core and a second facing material on the other side. The fiber cement facing that is used on at least one of the faces of the building material is 3/16" or less, more preferably 1/8" or less. The green fiber cement facing is preferably formed by a slurry-dewatering process to form a sheet that is in a plastic, uncured, state prior to manufacture of the composite. The composite building material is assembled in an uncured state and then cured.

- Lighter weight for ease of handling of full sheets and long lengths of product,
- Ease of cutting similar to gypsum wallboard to ensure quick and easy installation of the product by score-and-snap cutting with a utility knife,
- Low thermal conductivity for insulation of walls in building structures from the outside environmental conditions,
- Thermal fire insulation and low thermal shrinkage to provide resistance to the progression of heat and fire through building walls and ceilings,
- Low moisture transmission to control and direct moisture flow and permeation of water and moisture into building walls, ceilings and roofs, and
- Low acoustic transmission and high acoustic absorption to reduce noise transmission throughout rooms in a building.

The desired properties can be achieved with a sandwich composite design using fiber cement facing on a core having a composition tailored for the specific properties.

This invention in one embodiment generally pertains to a composite building material comprising a lightweight core with a thin fiber cement facing material or fiber cement skin bonded to one side of the core and a second facing material bonded to the other side. The fiber cement facing that is used on at least one of the faces of the building material is preferably less than about 3/16" thick, more preferably less than about 1/8" thick. Thinner skins provide an overall light composite because the skin material is of higher density than the core material. The fiber cement facing is preferably in a preformed green (uncured) state at the time of assembly of the skins and the core into the sandwich composite.

It is an object of this invention to produce composite building materials that can be designed specifically for applications such as but not limited to tile backer, wallboard, wall panel, siding, trim, sheathing, decking, flooring, structural members, fencing, roofing, roof decking, or substrates thereof. The bulk of the physical properties (strength, durability, etc.) can be tailored by varying the composition of the facing material and/or the core. The fabrication of composites with a particular set of mechanical properties can be done with the proper choice of facing material and thickness. The density of the composite can be reduced by foaming the core slurry and/or by adding low-density filler materials. The uncured fiber cement facings are preformed and preferably continuous in length. The use

formed such that the fiber cement component is in a plastic state and is uncured. A second component made from a curable material is formed adjacent the fiber cement component. At least the fiber cement component is cured while adjacent to the second component to form the building material.

In one preferred embodiment, the fiber cement component is a fiber cement skin, and the second component is a lightweight cementitious core having a first side and a second side. The fiber cement skin is positioned adjacent a first side of the cementitious core. The fiber cement skin and the lightweight cementitious core are simultaneously cured to form the building material.

Brief Description of the Drawings

Fig. 1 shows a cross-section of a 3-layer sandwich composite, comprising 2 facing layers or skins and a solid core.

Fig. 2 shows and exploded view of a 3-layer sandwich composite, comprising 2 facing layers or skins and a solid core.

Figs. 3A to 3C show examples of three of the many structural configurations that can be used for open-core composites. A vertical (open void cells are perpendicular to the skins) honeycomb core configuration is shown in Fig. 3A. A vertical configuration composed of symmetrically opposed corrugated core layers is shown in Fig. 3B. Fig. 3C shows a horizontal (open void cells are parallel to the skins), single corrugated core layer.

Fig. 4 shows a sandwich panel with a solid core. The first facing (10) covers one face and both sides and overlaps both side edges of the opposing face.

Fig. 5 shows a plank with a solid core and a first facing that envelops the faces and sides.

Fig. 6 shows a trim board with a solid core and a first facing that envelops the faces and sides.

Figs 7A-7G show cross-sectional views of additional composite products that can be made in accordance with preferred embodiments.

Detailed Description of the Preferred Embodiments

1. **Composite Structure and Composition**

A preferred embodiment of the composite building material is shown in Fig. 1. The composite is preferably comprised of a lightweight core (12a), a fiber cement outer layer, skin or facing (10), and a second outer layer, skin or facing material (14). As used herein,

- a hydraulic binder, preferably present in a concentration of about 10-80 wt%, more preferably about 20-50 wt%, and most preferably about 25-40 wt%;
- a filler material, preferably present in a concentration of about 0-80 wt%, more preferably about 40-70 wt%, and most preferably about 45-65 wt%;
- fiber, preferably present in a concentration of about 1-25 wt%, more preferably about 2-16 wt%, and most preferably about 5-12 wt%; and
- additives preferably present in a concentration of about 0-20 wt%, more preferably about 0-10 wt%, and most preferably about 0-6 wt%.

The hydraulic binder used in the fiber cement is preferably Portland cement but can also be any hydraulic cementitious binder chosen from a group including, but not limited to: high alumina cement, ground granulated blast furnace slag cement, gypsum hemihydrate, gypsum dihydrate, and gypsum anhydrite, or any mixtures thereof.

The filler, which can be reactive or inert material, is preferably ground silica sand but can also be any material chosen from the group including, but not limited to: amorphous silica, diatomaceous earth, rice hull ash, silica fume, microsilica, hollow ceramic spheres, geothermal silica, blast furnace slag, granulated slag, steel slag, fly ash, mineral oxides, mineral hydroxides, clays, magnesite or dolomite, metal oxides and hydroxides, polymeric beads, or any mixtures thereof.

The fiber cement additives can be chosen from a group including, but not limited to: silica fume, hollow ceramic spheres, cenospheres, geothermal silica, fire retardants, set accelerators, set retarders, thickeners, pigments, colorants, plasticizers, dispersants, foaming agents, flocculating agents, water-proofing agents, organic density modifiers, aluminum powder, kaolin, alumina trihydrate, mica, metakaolin, calcium carbonate, wollastonite, mineral oxides, mineral hydroxides, clays, magnesite or dolomite, metal oxides and hydroxides, pumice, scoria, tuff, shale, slate, perlite, vermiculite, polymeric beads, calcium silicate hydrate and polymeric resin emulsions, or any mixtures thereof. Preferred polymeric resins are products such as, but not limited to, acrylic latexes, styrene-butadiene latexes, or mixtures thereof. These latexes can be emulsions or be in a redispersible powder form. In portland cement-based materials, the latexes need to be stabilized to withstand the high-alkali environment.

separated into individual fibers. By far the most common process for individualized fiber used in fiber cement composite materials is the Kraft process.

The fibers are more preferably fibrillated cellulose fibers, such as described in Australian Patent No. AU 515151. Fibrillation of the fibers involves first dispersing the fibers in water. This is preferably carried out in a hydrapulper of the kind commonly used in the paper making industry. A disc-type cellulose refiner is preferably used to abrade, shred, or fray the fibers to produce short, hair-like fibrils or tendrils radiating from fine fiber strands. This process significantly increases the exposed surface area that is available for bonding when incorporated into a cementitious matrix. This fiber morphology enables improved fiber-matrix bonding which results in improved strength and improved impact and abuse resistance. This improved, more efficient reinforcement per unit volume of fiber added reduces the volume addition of fiber needed to attain a given performance level. This reduction in needed fiber content can significantly reduce raw material costs since cellulose fibers cost substantially more than the other fiber cement components.

In one embodiment, the fibers are dispersed at a consistency of about 1% to 6% in a hydrapulper, which also imparts some fibrillation. Further fibrillation can be achieved using a refiner or series of refiners. Once dispersed, the fibers are then fibrillated to a range of about 100 to 750 degrees of CSF (Canadian Standard Freeness), more preferably between about 100 to 650 degrees of CSF, more preferably between about 180 to 650 degrees of CSF. Dispersion and fibrillation can also be achieved by other techniques such as hammer-milling, deflaking, refining, shredding, and the like. Furthermore, use of fibers without fibrillation is also acceptable for some products and processes. In another embodiment, processing further comprises flash drying the fibers to a moisture content of about 5% to 50% using conventional flash drying systems.

The orientation of the fibers in the facing layers of fiber cement is preferably parallel to the planar layers of the material and this planar orientation raises the tensile strength of the skins 10 to 20% compared to random-oriented fiber in fiber-reinforced cement and concrete facings. More preferably, the fibers are substantially oriented in the direction of loading. It will be appreciated that the fibers can also be aligned in different planes to correspond to the desired direction of loading. The utilization of planar-oriented fibers is a more economical use of fiber. This is because fiber is more expensive than the inorganic matrix materials. Less fiber is needed to achieve the desired strength and the

These processes may also include post-forming processes such as pressing, embossing and others, after the article is formed but before the article is cured. The processing steps and parameters used to achieve the final product using a Hatschek process are similar to what is described in Australian Patent No. 515151. Thus, after the processing described above, the formed article is in a plastic state, enabling it to retain its shape and be capable of molding, but is not yet cured. Curing of the article, as described below, preferably occurs simultaneously with the core material.

b. Core Structure and Material

The core structure can be that of either a solid core (element 12a in Fig. 1 and Fig. 2) or an open core (elements 12b, 12c, and 12d in Figs. 3A, 3B, and 3C, respectively). Alternatively, the core can be considered to be homogeneous or non-homogeneous (i.e., the core is itself a composite). One or a combination of the following methods can be used to reduce the composite density:

- by assimilating large volumes of foam, with a bubble size preferably in the range of about 0.02-1 mm, into the core slurry (solid core structure),
- by adding large volumes of low density materials to the core slurry (solid core structure), or
- by forming the core with structural reinforcing material in such a way as to form an open network having a large void volume (structural porosity, with void dimensions typically ranging from about 10% to 90% or more of the core thickness), but with a structural design that produces adequate core strength (open core structure).

Large volumes of foam can be introduced to the core by adding foaming agents directly to the slurry and foaming in situ, or preferably by adding foam from a foam generator. Voids can also be formed by adding a reactive gas-forming metal powder to the alkaline cementitious slurry, such as aluminum powder, to generate gas voids. Low-density additives are added directly to the slurry and require no additional processing. Fabrication of an open core structure involves construction of the core prior to assembly of the composite.

For the open core structural design, the core is preferably made from a strong material in a shape and orientation that structurally reinforces and supports the facing materials. The objective is to create the strength and stability of a monolithic sandwich

in addition to or in place of foaming agents to reduce core density. Lightweight fillers include expanded minerals such as perlite, vermiculite, shale, and clay, expanded polystyrene spheres, and fly ash. Moisture resistant additives used individually or in combination in these cores include emulsions of wax and/or asphalt, polyvinyl alcohol, siloxane emulsion, metallic soaps and stearates. Films or resinous coatings formed by such materials as styrene-acrylic latex can be used to further improve moisture resistance and surface quality. Additives used to improve fire resistance include gypsum, mineral fibers such as glass and wollastonite, mineral additives such as unexpanded vermiculite, mica, hydrated alumina, bauxite, clay, and any combinations thereof.

Other materials that can be used for the core include those described for the facing material above, those described in the section entitled "Overview of Other Sandwich Composite Embodiments."

c. Materials for the Second Outer Layer, Skin, or Facing

The second layer, or skin, if used, can be supplied in any generally planar form, such as a continuous fibrous or fiber-reinforced composite sheet, mat, plate, film, or coating, and can be made from substances such as metals, plastics, wood, paper, organic or inorganic fibers, cementitious or non-cementitious binders, fillers, additives, or combinations thereof. Preferred non-cementitious binders include but are not limited to polymers such as acrylic and styrene-butadiene latexes. In one embodiment, the second facing is fiber cement manufactured like the first facing described above. In another embodiment, the second facing is made of a different material from the first facing. The preferred materials to be used for the second skin include thin fiber cement, fibrous mats, paper, continuous strand two-dimensional mats, and polymeric coatings. The preferred fibrous mats are made from fiberglass, and can be either nonwoven (veils) or woven (scrims) using continuous or chopped fibers. The glass fibers are preferably alkali resistant or polymer coated. The surface of the second layer can be shaped, embossed, or patterned if needed for aesthetics or functionality. Other examples that can be used for the second facing are described in the section below entitled "Overview of Other Sandwich Composite Embodiments."

d. Composite Processing

It is preferred that after the manufacture of the components above, the composite is cured sufficiently to attain a minimum level of stiffness before subsequent processing. If a

Manufacturing of the composite is done with an uncured fiber cement sheet to produce stronger interfacial layer bonding to resist or essentially eliminate core-skin delaminations during handling, cutting, installation, and service. Co-curing of the core and skins produces a mutually interpenetrating mechanical and chemical bonding between the core and fiber cement skin. This type of bonding is stronger and more durable compared to forming the composite using cured fiber cement skins and does not require adhesive to bond the layers together. An accelerated hydraulic binder is preferably used to speed up continuous processing and enable higher throughput. The use of fiber cement facings gives the composite excellent moisture and abuse resistance. Good fire resistance can be obtained by the use of additives that effectively slow fire thermal conduction and control the permeability of the microstructure. The composites can also be designed to have interlayers, comprised of organic or inorganic materials or mixtures thereof, that provide special functionality such as by improving core-skin bonding, moisture control, thermal insulation, and fire protection.

The use of accelerating agents results in rapid stiffening desired for the high speed, continuous production of the composites. Penetration of the accelerants in the core slurry into the uncured facings during manufacture can accelerate the cure of the fiber cement facings. High production rates require the rapid stiffening of the composite to enable handling for cutting and stacking without collapse of the cores or damage to the composites.

The use of pre-formed, uncured fiber cement skins offers a number of advantages as outlined below: First, improved skin-core bonding resulting from mutually interpenetrating mechanical and chemical bonding. This improved bonding produces higher bending strengths because this type of bonding is stronger and more durable than the predominantly mechanical bonding that occurs between cured fiber cement and the core found in the prior art. In addition, the improved bonding results in improved resistance to or elimination of core-skin delaminations that can occur during handling, cutting, installation, and service.

The use of pre-formed, uncured fiber cement skin also results in reduced manufacturing time. The uncured skins can be concurrently manufactured and shaped, imprinted, or embossed prior to assembly of the composite. An uncured bottom skin can also act as a carrier sheet and, by bending the flexible skin material upward at the edges, it can act as a mold for the core material, enabling continuous production of the composite.

shown in Figs. 7D-7F, the building material need not be circular in shape, but can assume many other forms as well. Figs. 7D-7F illustrate one embodiment in which a rectangular core of lightweight material 24 is surrounded by a fiber cement facing 22 that extends all the way around the lightweight core 24. This facing 22 need not extend all the way around the core 24, but can also extend only partially around the core.

Further embodiments are illustrated in Figs. 7E and 7F, wherein a core 26 is provided surrounded by two facing layers 24 and 26, one of which may be fiber cement as described above and the other of which can be the same or other material. In Fig. 7F, it is illustrated that the core 26 can be hollow.

Fig. 7G illustrates another embodiment wherein a lightweight core 30 is sandwiched between two facing layers 28 and 34, which may be fiber cement facings such as described above. The core 30 may be a composite material itself, reinforced with an exemplary reinforcement 32, which may be fibers or other materials.

2. **<u>Examples of Preferred Fiber Cement Skin Building Materials</u>**

One preferred embodiment of the invention comprises a building material made from a lightweight, cement-containing, low-cost core which is at least partially surrounded by a fiber cement skin of thickness of less than about 3/16" thick, which when cured, is of high durability when exposed to sunlight, water, and atmospheric gases. The bonding between the fiber cement skin and the lightweight core is cementitious. The thin, uncured fiber cement skin is capable of being bent, folded, or profiled. Parts of the core surface that are not exposed to external weathering conditions may be left unfaced or faced with another sheet material herein described as the second outer layer, as desired.

The composite preferably has one or more of the following improved attributes, including lower cost, durability and workability (including handling, cutting to shape, and fixing). Moreover, multifunctional performance is accomplished incorporating any combination of strength, abuse resistance, fire, acoustical transmission, and aesthetics by the use of sandwich composites as described above. In terms of manufacturability, the use of thin green sheet allows the skin to form a shapeable mold for the core. Additives enable the core and skin to be rapidly and controllably cured to form a cementitiously bonded monolith.

The use of pre-formed, uncured fiber cement skins in the production of sandwich composite boards is also far more efficient than using cured fiber cement skins. The use of

equivalent to type X gypsum wallboard when tested to ASTM E 119 for interior and exterior wall and ceiling assemblies. The advantage of this material is that it provides both fire resistance and a durable exterior surface in a single product. Traditional systems require multiple building products to attain equivalent functionality, such as the combination of a type X gypsum wallboard and an exterior cladding.

b. Thermal Insulation + Cladding or Substrate

Another example of a preferred product combines the desirable properties of fiber cement with a thermal insulating core material to achieve higher R-values when tested in accordance with ASTM C-177. The advantage of this material is that it provides both thermal insulation and a durable exterior surface to the structure. Traditional systems require a combination of building products to attain equivalent functionality, such as the combination of a foam plastic thermal insulation panel and an exterior cladding.

c. Fire + Thermal Insulation + Cladding or Substrate

Another example of a preferred product combines the desirable properties of fiber cement with a thermal insulating core material to achieve higher R-values when tested in accordance with ASTM C-177, and also achieves a fire resistive rating equivalent to 5/8" thick type X gypsum wallboard. The advantage of this composite material is that it provides a fire resistive material, a thermal insulating material, and a durable exterior surface to the building assembly. Traditional systems require multiple building products to attain equivalent functionality, such as the combination of a type X gypsum wallboard, a foamed plastic thermal insulation panel, and an exterior cladding.

d. Shear + Cladding or Substrate

Another example of a preferred product combines the desirable properties of fiber cement with the racking shear strength, tested in accordance with ASTM E 72, that is provided by fixing the composite material in a framed assembly. The advantage of this material is that it provides the necessary shear strength in an assembly that has a durable exterior surface that is non-combustible and has low surface burning characteristics (when tested to ASTM E 84). Traditional systems such as APA Rated Sheathing and Siding are combustible and have higher surface burning characteristics.

e. Shear + Fire + Cladding or Substrate

Another example of a preferred product combines the desirable properties of fiber cement with a fire resistive core to achieve a fire rating equivalent to type X gypsum

can be positioned so that the composite has all its layers aligned in the oriented direction, such as with fiber cement, or with alternating layers aligned at right angles, such as with plywood. Aligning of adjacent, oriented layers at right angles greatly reduces the directionality in the composite properties.

Sandwich composites normally contain at least three primary layers and are typically constructed of outer skins or facings covering relatively lightweight cores. The facing material of sandwich composites is usually chosen to impart strength to the composite. Exterior durability and moisture resistance frequently are not inherent properties of the high-strength skins. Fiber cement skins provide moisture resistance and durability that are desired for exterior building products such as siding, wall panels, trim, soffit, shingles and roofing tiles. High strength and low weight composites are desired for ease of installation of building products. This enables large sheets to be handled without excessive physical exertion and without the sheet breaking in bending. Additions of foam and/or lightweight fillers to the core mix of the sandwich composite reduce the overall weight of the composite.

b. Sandwich Composite Design Considerations

A sandwich composite structure, employing a lightweight core and relatively high tensile strength skins or facings, allows composite materials to be made thick enough to impart structural rigidity without rendering the product too heavy for ease of handling. The flexural strength of the composite is determined mainly by the tensile strength of the skins as long as the strength of the bonded interface between the skins and core is adequate. Failure due to bending of a sandwich composite can occur in three distinct ways. The face in tension may fracture, the face in compression may buckle and/or delaminate from the core, or the core may fail under shear load. Failure under shear load can occur either close to the interface of the core and skin, or within the core itself. Good interfacial bonding between the core and skins is needed when using lightweight core materials that commonly have high pore volumes.

c. Facing Materials of Building Material Sandwich Composites

Facing materials, or skins, are generally in the form of planar materials, comprised of sheets, mats, plates, films, and coatings. These facings can be made from substances such as metals, plastics, wood, paper, organic or inorganic fibers, and cementitious materials. Facing materials used for sandwich composite building materials as described

be 1.75 mm for the gypsum wallboard, compared to < 0.01 mm for the fiber cement wallboard.

(3) Flame and Fire Spread of Facing Materials

Another concern when designing and selecting building materials is the resistance of the surface of the material to promoting the spread of a fire and to supply fuel to a fire in a building. The surface fire resistance of paper-faced building products is poor compared to cement-based or inorganic-based materials due to the combustibility of the wood fiber in the paper facing.

(4) Fibrous-Mat Facings

When fibrous mats are used on wallboards, sheathing, and backing boards, they are usually made from uncoated or coated fiberglass. Fibrous mats can be either nonwoven (veils) or woven (scrims), and are composed of either chopped or continuous fibers. Scrims are generally more expensive than veils, but typically are stronger and more durable. Fibrous mats are more durable than paper facings. Although paper facings are generally stronger when dry, fibrous mats have much higher wet strengths. ASTM C1154-99 defines fiber-mat reinforced products (FMC) as "manufactured thin section composites of hydraulic cementitious matrices and non-asbestos fibers in two-dimensional scrims".

(a) Non-Woven Fiberglass-Mat Facings

Fiberglass mats have been used to improve the moisture and fire resistance of gypsum board products. However, the composites are still susceptible to deterioration after prolonged exposure to moisture due to the solubility of gypsum in water. This can gradually reduce the strength of the core and of the mat-core interface. Another concern with fiberglass mat facings is skin irritation from handling the composites. The glass fibers contained in the mats are typically less than 0.001 inch in diameter and can fracture and become embedded in skin that comes into contact with the mats during handling. These embedded pieces of fiberglass cause irritation of the skin. Polymeric coatings have been claimed to further improve the water resistance of both paper and fiberglass facings. Such coatings generally slow the rate of water permeation into the core material.

(b) Fiberglass Scrims

Fiberglass scrims are used to reinforce board products such as Portland cement-based ceramic tile backing boards. However, the durability of fiberglass scrims made from A-glass (soda-lime-silica) or E-glass (borosilicate) is greatly reduced when they are used in

structural walls, panels, beams, girders, and joists, use prefabricated, cured sheets as rigid frameworks into which the cores are cast (Jones, Jr., U.S. Patent No. 5,473,849). The composites are not designed to be installed onto a supporting wall framing like most wallboards or wall sheathings, but instead span from floor to ceiling, like partition composite wall panels. The method of forming this composite is similar to pouring concrete between formwork sheets, except the fiber cement facings (analogous to the formwork) are permanent in this case. The art of forming such composites requires the fiber cement skin to be thick enough to be handled without damaging the panel and strong enough to withstand the hydrostatic pressures generated from the core mix during casting of the core. The fiber cement facings are ≥ 3/16" thick to provide sufficient strength for processing the composite. There is also preferably a good bond between the facings and core, whereas formwork is intended to have negligible bonding to the concrete so that it can be removed and reused. A similar method uses a mold to form building panel composites (Cottier, et al., Australian Patent No. 661,704). The core is cast onto a cured fiber cement facing sheet and then covered with a top fiber cement facing sheet.

(b) Co-formed Fiber Cement Sandwich Composites

The three classifications that are used to describe the different reinforced composite building products in ASTM C 1154-99 are cement-bonded particle board, fiber cement and fiber-mat reinforced cement.

Uncured cement-bonded particle board and fiber-mat reinforced cement (FMC) facings are formed in-place as part of composites that are fabricated from sequentially deposited layers. The skins and the core are co-formed in one process to produce the sandwich composite. The bottom facing material is formed first, followed by the core material, and then the top facing material. These composites can be continuously formed monoliths that are cut and trimmed to size, or individually molded to the desired size. The core and skin materials can be slurries of different compositions that are cast or sprayed, or granular materials that are pressed to consolidate the composite.

An example of a co-formed sandwich material is described in U.S. Patent No. 5,693,409 to Gnatowski et al. This material is processed by a sequential deposition of layers and describes facing layers as fiber cement. The description of fiber cement used in Gnatowski is different from the fiber cement of the preferred embodiments above, which is the same as the description given in ASTM C1154-99. The difference in the materials,

method and the cores contain large volumes of foam or sufficient quantities of low-density fillers to yield a relatively lightweight composite. The most common method of adding large volumes of voids to a core slurry is by mixing it with foam generated using a foaming agent. This results in a randomly distributed multitude of small pores. Cellular concrete is a typical core material and is defined in ASTM C 125-96 as lightweight, hydraulic cement having a homogenous void or cell structure attained using gas-forming chemicals or foaming agents. The foam, fillers, and admixtures needed for the desired core properties can be bound together by either organic (polymeric) or inorganic binders. The most common type of binder used in building materials is an inorganic, hydraulic binder. The most common and economical inorganic, hydraulic binders are gypsum and Portland cement.

(1) Structural Open-Framed Cores

The second method of producing lightweight cores involves the use of an open reinforcing framework. The core is made from a strong material in a shape and orientation that structurally reinforces and supports the facing materials. The objective is to create the strength and stability of a monolithic sandwich composite using an open structural design that incorporates large volumes of void space to reduce the composite weight. Such structural designs include open honeycombs and corrugations.

(2) Core Compositions

Typical admixtures for cementitious core slurries include viscosity modifiers, accelerators, retarders, foaming agents, dispersing agents, and additives to improve moisture and fire resistance. Lightweight aggregates or fillers are used in addition to or in place of foaming agents to reduce core density. Lightweight fillers include expanded minerals such as perlite, vermiculite, shale, and clay, expanded polystyrene spheres, and fly ash. Moisture resistant additives used individually or in combination in gypsum cores include emulsions of wax and/or asphalt, polyvinyl alcohol, siloxane emulsion, and metallic soaps. Films or resinous coatings formed by such materials as styrene-acrylic latex are used to further improve moisture resistance and surface quality. Additions used to improve fire resistance include gypsum, mineral fibers such as glass and wollastonite, mineral additives such as unexpanded vermiculite, mica, hydrated alumina, bauxite, clay, and combinations of thereof.

with mineral fiber to achieve a one-hour fire resistance rating. This type of installation therefore results in higher costs, requiring extra materials and more time to install. This insulated wall does have the advantage of providing a fiber cement surface to one side of the wall that can be used in high traffic areas subject to abuse, or as a substrate for ceramic tiles. Preferred embodiments of the current invention describes a superior product that provides a fiber cement building board composite material that can achieve the fire resistance performance of gypsum wallboard and also the abuse resistance, moisture resistance, and durability of fiber cement.

In general, prior art sandwich composites utilizing fiber cement skins on both sides of a lightweight core were limited to using a thickness of material that could be handled and formed into a composite. The skins were greater than or equal to about 3/16" in thickness and were cured to provide sufficient strength for handling and forming into the composite material. This product was formed into thicknesses of 1-½" or greater to span from floor to ceiling as full wall panels or wall partitions. The preferred embodiments described above are an improvement on this prior art because thinner skins of fiber cement are used to form the sandwich composite. This is achieved without having the handling problems of the prior art because the thin fiber cement skins are formed into the sandwich composite in a green sheet form that is plastic and uncured. The plastic nature of the skin during formation of the composite provides improved design flexibility to enable forming flat surfaces, textures, and profiled forms of the composite. The thin fiber cement skins also allow a lighter weight and thinner composite material to be produced that can be attached to wall framing in full sheets typical of gypsum wallboards and wall sheathing. An overall lighter weight composite is achieved because more of the lightweight core is used in a given board thickness due to the use of thinner skins.

Thus, the fiber cement sandwich composite of the preferred embodiments provides a lightweight wallboard/sheathing composite that is easy to handle, to nail, to score-and-snap, and that has the strength, durability, moisture resistance, and abuse resistance of fiber cement, along with the thermal insulation and fire resistance of gypsum.

It should be understood that certain variations and modifications of this invention will suggest themselves to one of ordinary skill in the art. The scope of the present invention is not to be limited by the illustrations or the foregoing descriptions thereof, but rather solely by the appended claims.

13. The building material of Claim 1, wherein the fibers are oriented parallel to the fiber cement a surface of the first component.

14. The building material of Claim 1, wherein the fiber cement of the first component includes cellulose fibers.

15. The building material of Claim 1, wherein the fiber cement of the first component includes natural inorganic fibers.

16. The building material of Claim 1, wherein the fiber cement of the first component includes synthetic fibers.

17. The building material of Claim 1, wherein the fiber cement of the first component includes engineered fibers.

18. The building material of Claim 1, wherein the second component is a lightweight material.

19. The building material of Claim 1, wherein the second component is a fire resistive material.

20. The building material of Claim 1, wherein the fiber cement of the first component is pressed.

21. The building material of Claim 1, wherein the fiber cement of the first component is unpressed.

22. The building material of Claim 1, wherein the fiber cement of the first component is moldable.

23. The building material of Claim 1, wherein the fiber cement of the first component is embossed.

24. The building material of Claim 1, further comprising a sub layer between the first component and the second component to improve bonding therebetween.

25. The building material of Claim 1, wherein the second component is a lightweight core having a first side and a second side, and the first component is a pre-formed fiber cement facing on at least the first side of the core.

26. The building material of Claim 25, further comprising a second facing on the second side of the core.

27. The building material of Claim 25, wherein the fiber cement facing wraps around both the first side and the second side of the core.

43. The building material of Claim 41, wherein the first component and the second component are sequentially cured.

44. The building material of Claim 40, further comprising partially drying the fiber cement component after forming the second component and before curing at least the fiber cement component.

45. the fiber cement component prior to wherein the first component is dried before providing the first component adjacent the second component.

46. The method of Claim 40, further comprising providing the fiber cement component on one side of the second component.

47. The method of Claim 46, further comprising providing a third component adjacent a second side of the second component.

48. The method of Claim 47, wherein the third component is made of fiber cement.

49. The method of Claim 40, wherein the fiber cement component has a thickness of less than about 3/16".

50. The method of Claim 40, wherein the pre-formed fiber cement component comprises fibers that are substantially aligned along the same plane.

51. The method of Claim 40, wherein the fiber cement component includes individualized fibers.

52. The method of Claim 40, further comprising providing the fiber cement component at least partially around the second component.

53. The method of Claim 40, wherein the second component is a made of a lightweight cementitious material.

54. The method of Claim 40, wherein the second component is a made of a fire resistive material.

55. The method of Claim 40, further comprising molding the pre-formed fiber cement component into a desired shape while the component is in its uncured, plastic state.

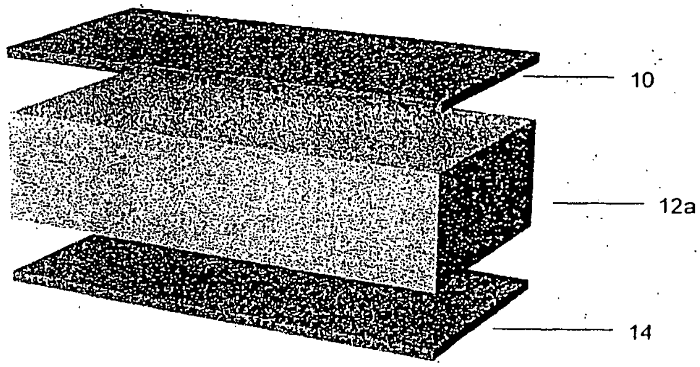


Fig. 2

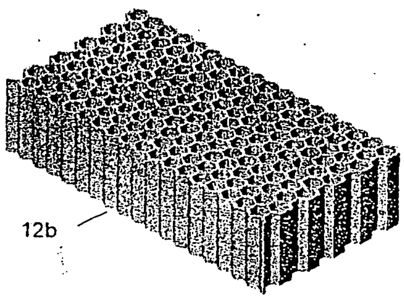


Fig. 3A

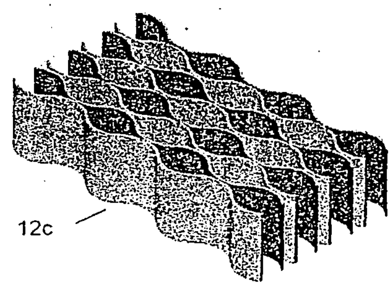


Fig. 3B

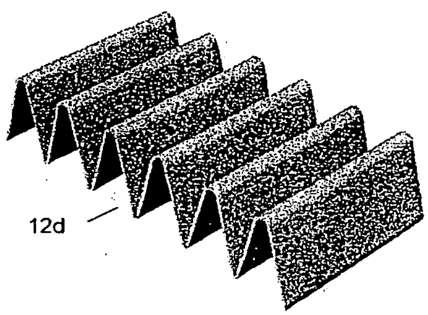


Fig. 3C

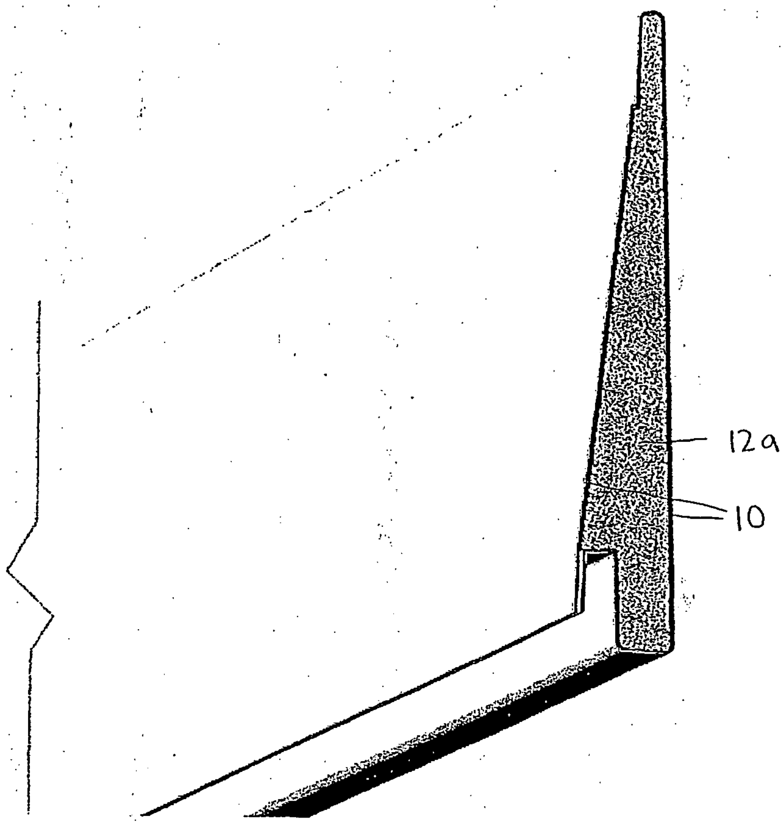


Fig. 5
(plank)

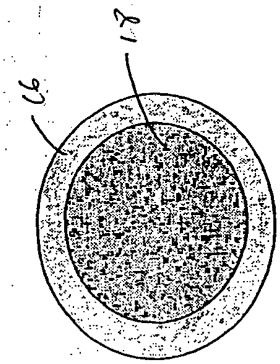


FIG. 7A

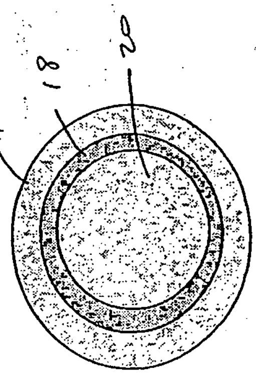


FIG. 7B

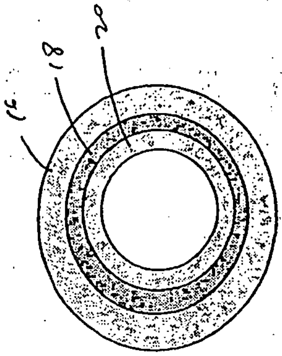


FIG. 7C

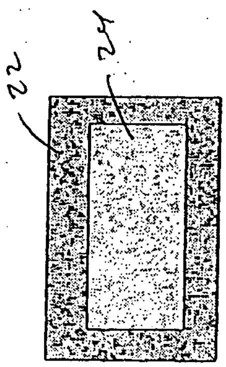


FIG. 7D

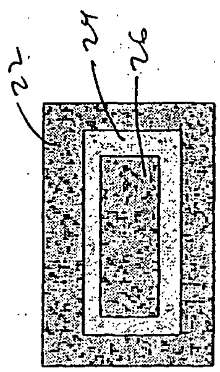


FIG. 7E

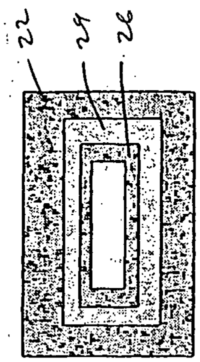


FIG. 7F

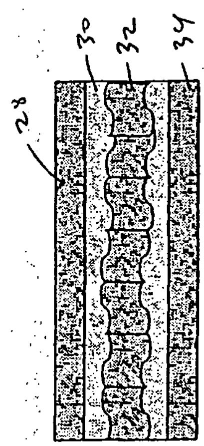


FIG. 7G

INTERNATIONAL SEARCH REPORT

Inte... application No
PC... /01/30967

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 4265979	A	05-05-1981	US	4233368 A	11-11-1980
			AU	531875 B2	08-09-1983
			AU	4764779 A	13-12-1979
			CA	1121994 A1	20-04-1982
			EP	0020345 A1	07-01-1981
			GB	2022503 A ,B	19-12-1979
			IL	57518 A	30-07-1982
			WO	8000013 A1	10-01-1980
US 4252767	A	24-02-1981	BR	7603965 A	22-03-1977
			CA	1069263 A1	08-01-1980
			CA	1069334 A2	08-01-1980
			DE	2552460 A1	16-06-1976
			FR	2294291 A1	09-07-1976
			GB	1547370 A	13-06-1979
			GB	1547369 A	13-06-1979
			IE	42359 B1	30-07-1980
			IE	42358 B1	30-07-1980
			JP	51085227 A	26-07-1976
			MX	3029 E	20-02-1980
			NL	7514263 A	11-06-1976